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ANALYSIS OF TWO AREA FRAME BASED
SAMPLING DESIGNS FOR THE JUNE
AGRICULTURAL SURVEY₌₌

Darla J. Kuznia

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ANALYSIS OF TWO AREA FRAME BASED SAMPLING DESIGNS FOR THE JUNE AGRICULTURAL SURVEY. by Darla J. Kuznia, Research and Applications Division, Ohio Field Research Unit, National Agricultural Statistics Service, United States Department of Agriculture, Washington, D.C. 20250, 1992, NASS Staff Report No. SRB-92-4.

ABSTRACT

This report presents the results of comparing two different area frame based sample designs for the June Agricultural Survey (JAS). The two designs involve the use of a 320 acre target segment size versus the use of a 640 acre target segment size. During the 1990 June Agricultural Survey (JAS), personnel from the Area Frame Section began converting the area frame design from a 320 acre target segment size to a 640 acre target segment size for Ohio and North Carolina. The primary reason for this change was to produce more resident farm operators (RFO's) and agricultural tracts to satisfy future sampling needs.

The 1990 JAS for Ohio and North Carolina used both 320 and 640 acre target segments in strata 11, 12, 13 and 20. When sample sizes were chosen appropriately, both designs would yield approximately the same number of resident farm operators and agricultural tracts. However, more area must be sampled for the 640 acre target segment design. A two-sample t-test was used to assess any difference in the mean number of resident farm operators or agricultural tracts for the two sampling designs. No significant differences were found for North Carolina. A significant difference in RFO's did occur in stratum 11 for Ohio.

KEY WORDS

agricultural tracts, area sampling frame, resident farm operators, segment, strata

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SUMMARY

During the 1990 June Agricultural Survey (JAS), personnel from the Area Frame Section began converting the area frame design from a 320 acre target segment size to a 640 acre target segment size for Ohio and North Carolina. Approximately one half of the target segment sizes of 0.5 square mile (320 acres) were increased to 1.0 square mile (640 acres) for strata 11 and 12 in Ohio and strata 13 and 20 in North Carolina. Hence, for Ohio and North Carolina, the 1990 JAS was a split sample containing two separate sample designs. The primary reason for making the conversion was to increase the number of resident farm operators (RFO's) and the number of agricultural tracts (AGTRACT's) to satisfy future sampling concerns.

When the expected totals from the two sampling designs (320 acre target segment size versus the 640 acre target segment size) were compared, the sample design for the 640 acre target segment design (SD-640) showed an increase over the 320 acre sampling design (SD-320) for both variables. However, this result was expected since SD-640 had more acreage in the survey sample than the alternate design. Hence, a comparison was made between the two designs for equal sized segments. Summary statistics, the F-test for equal variances, and the two-sample t-test were used to assess whether any differences occurred due to the use of the different sample designs in terms of the variables for number of resident farm operators and number of agricultural tracts for strata with sufficient degrees of freedom. The same analysis was performed for all strata. For stratum 11 in Ohio, the mean number of RFO's was significantly larger for the SD-320 design as compared to the SD-640 design. However, for North Carolina, no statistically significant differences were found with respect to the two different sample designs.

INTRODUCTION

Personnel from the Area Frame Section began implementing a new sample design in selected land use strata for Ohio and North Carolina for the 1990 June Agricultural Survey (JAS). This new design involved converting the 320 acre target segment size to a 640 acre target segment size for approximately one half of the sampled segments in strata 11 and 12 in Ohio and strata 13 and 20 in North Carolina (see Appendix A). Consequently, the 1990 JAS was a split sample in these strata containing two separate sample designs. The main reason for making the change was to increase the number of resident farm operators (RFO's) and the number of agricultural tracts (AGTRACT's) for future sampling concerns. The expected totals from the two sampling designs (320 acre target segment size versus the 640 acre target segment size) were compared. Also, summary statistics, the F-test for equal variances, and the two-sample t-test were used to assess whether any differences occurred between the number of RFO's and AGTRACT's through the use of the different sample designs.

METHODS

The variable RFO was coded "1" for farmers living within the segment and "0" for farmers living outside the segment. Similarly, the variable AGTRACT was coded "1" for tracts with agricultural acreage and "0" for tracts with agricultural acreage equal to zero. Means, variances, and degrees of freedom were estimated using formulae pertaining to the stratified random sampling design of the JAS (see Appendix B and C). To find the estimators, the number of agricultural tracts and resident farm operators were summed to the segment level and then summed to the paper strata level (see Appendix D).

In order to compare the total expected number of RFO's and AGTRACT's produced from each sampling scheme, the number of observations selected for each scheme was determined. The number of segments for SD-320 was determined by using the number of segments sampled in the 1989 JAS when all target segment sizes were 320 acres. Hence, multiplying the number of segments sampled in the 1989 JAS by the SD-320 means for RFO and AGTRACT from the 1990 JAS produces an estimate of the total expected number of RFO's and AGTRACT's for this sample design. Similarly, the total expected number of RFO's and AGTRACT's were found for SD-640 by multiplying the SD-640 means for RFO and AGTRACT from the 1990 JAS by the number of segments sampled in the 1991 JAS when all the target segment sizes were 640 acres. Therefore, the difference between

the expected totals of SD-640 and SD-320 gave an indication of the increase in farms and agricultural tracts when using SD-640. The ratio of SD-640 to SD-320 gave an indication of the percent increase when using SD-640. These data are shown in RESULTS I.

Next, several assumptions were made to ensure proper use of the procedures. First, both sample designs were independent stratified random samples. Second, the two samples were normally distributed such that the sample under SD-320 x_1, \dots, x_{n_1} was from a $N(\mu_{320}, \sigma_{320}^2)$ and the sample for SD-640 y_1, \dots, y_{n_2} was from a $N(\mu_{640}, \sigma_{640}^2)$. Considering the variable RFO, x_i was the number of RFO's in segment i in the SD-320 sample which has n_1 segments, and y_j was the number of RFO's in segment j in the SD-640 sample which has n_2 segments. Further, since SD-640 has a segment which was two times the size of SD-320's segment, units had to be adjusted such that both samples were in terms of the same area. For example, one would expect that there would be twice the number of resident farm operators in a 640 acre sized segment as compared to a 320 acre segment because the area was twice as large. Hence, to assess the two sampling plans fairly, both distributions were expressed in terms of 100 acres rather than 320 acres or 640 acres. Therefore, at the segment level, the counts related to both SD-320 and SD-640 samples were divided by constants of 3.2 and 6.4 respectively. These transformations resulted in a common segment size of 100 acres. Let $x_{(adj)1}, \dots, x_{(adj)n_1}$ and $y_{(adj)1}, \dots, y_{(adj)n_2}$ be the new adjusted samples. An F-test (test for equal variances) and a two-sample t-test (test for equal means) were performed to compare the adjusted stratified random samples. These data are shown in RESULTS II.

RESULTS I

The expected total number of RFO's and AGTRACT's for each sampling scheme was calculated by multiplying the mean found from the 1990 JAS for RFO and AGTRACT by the appropriate number of segments sampled. Recall, for SD-320, the number of segments was equal to the 1989 JAS segment sample size and for SD-640, the number of segments was found from the 1991 JAS. Tables 1 and 2 list this estimated "n", the mean number of RFO's and AGTRACT's from the 1990 JAS, the expected total the sample would produce based on those sample sizes, the estimated variance of the estimated total, and the total area of the simulated sample.

Table 1: Expected total number of RFO's produced from SD-320 and SD-640

| STATE | STRATA | TARGET SEGMENT SIZE | ESTIMATED "n" (YEAR) | 1990 JAS RFO MEAN | 1990 JAS RFO VARIANCE | EXPECTED TOTAL (VARIANCE) | TOTAL AREA (ACRES) |
|-------|--------|---------------------------|----------------------------|-------------------------|-----------------------------|------------------------------|--------------------------|
| OH | 11 | 320 | 140 (1989) | 1.24 | 0.015 | 173.3 (284.5) | 44,800 |
| OH | 11 | 640 | 105 (1991) | 2.32 | 0.054 | 243.7 (598.8) | 67,200 |
| OH | 12 | 320 | 55 (1989) | 1.82 | 0.052 | 100.0 (157.7) | 17,600 |
| OH | 12 | 640 | 55 (1991) | 2.86 | 0.263 | 157.5 (796.5) | 35,200 |
| NC | 13 | 320 | 30 (1989) | 1.11 | 0.083 | 33.3 (74.5) | 9,600 |
| NC | 13 | 640 | 30 (1991) | 1.50 | 0.096 | 45.0 (86.4) | 19,200 |
| NC | 20 | 320 | 210 (1989) | 0.73 | 0.008 | 153.0 (345.5) | 67,200 |
| NC | 20 | 640 | 140 (1991) | 1.52 | 0.052 | 212.5 (1009.9) | 89,600 |

Table 2: Expected total number of AGTRACT's produced from SD-320 and SD-640

| STATE | STRATA | TARGET SEGMENT SIZE | ESTIMATED "n" (YEAR) | 1990 JAS AGTRACT MEAN | 1990 JAS AGTRACT VARIANCE | EXPECTED TOTAL (VARIANCE) | TOTAL AREA (ACRES) |
|-------|--------|---------------------------|----------------------------|-----------------------------|---------------------------------|------------------------------|--------------------------|
| OH | 11 | 320 | 140 (1989) | 3.99 | 0.031 | 558.3 (610.9) | 44,800 |
| OH | 11 | 640 | 105 (1991) | 6.61 | 0.102 | 693.7 (1129.0) | 67,200 |
| OH | 12 | 320 | 55 (1989) | 4.03 | 0.077 | 221.7 (233.0) | 17,600 |
| OH | 12 | 640 | 55 (1991) | 6.09 | 0.366 | 334.9 (1108.1) | 35,200 |
| OH | 13 | 320 | 30 (1989) | 4.33 | 0.417 | 130.0 (375.5) | 9,600 |
| OH | 13 | 640 | 30 (1990) | 5.50 | 0.672 | 165.0 (605.0) | 19,200 |
| OH | 20 | 320 | 210 (1989) | 2.93 | 0.029 | 615.0 (1298.8) | 67,200 |
| OH | 20 | 640 | 140 (1990) | 4.84 | 0.163 | 677.5 (3190.7) | 89,600 |

From Tables 1 and 2, SD-640 produced more RFO's and AGTRACT's in every single case. However, the total area of the sample also increased every time for this sampling scheme.

Tables 1 and 2 were summarized in Table 3 as follows: the expected total from SD-320 was subtracted from the expected total from SD-640. Also, the ratio of the expected totals was found.

Table 3: Difference of expected totals and ratio of expected totals

| STATE STRATA | EXPECTED TOTAL RFO DIFFERENCE | EXPECTED TOTAL RFO RATIO | EXPECTED TOTAL AGTRACT DIFFERENCE | EXPECTED TOTAL AGTRACT RATIO |
|-----------------|-------------------------------------|--------------------------------|---|------------------------------------|
| OH 11 | 70.4 | 1.41 | 135.4 | 1.24 |
| OH 12 | 57.5 | 1.58 | 113.2 | 1.51 |
| NC 13 | 11.7 | 1.35 | 35.0 | 1.27 |
| NC 20 | 59.5 | 1.38 | 62.5 | 1.10 |

For example, if the two simulated samples were implemented as designed in stratum 11 for Ohio (est "n" and appropriate segment sizes being used), one would expect to get 70.4 more resident farm operators in SD-640 over SD-320. Further, SD-640 would give approximately 41% more resident farm operators over the SD-320. Note, changing the est "n" would change the totals and the results, and consequently, the number of segments sampled could be adjusted appropriately such that both designs give approximately the same number of RFO's and AGTRACT's. Because the 640 acre target segment is twice as large as the 320 acre target segment, if the ratio of expected totals for the variable RFO was 2 then both designs would be capturing the same amount of farms. All the ratios are less than 2, which indicated that more area must be sampled in a 640 acre sample design to achieve the same number of resident farm operators or number of agricultural tracts. However, data collection costs are also lower for the SD-640 design, since travel to a randomly selected segment site is a major portion of the data collection cost.

RESULTS II

First, a test was performed to check if the variances of $\overline{Y}_{(adj)}$ and $\overline{X}_{(adj)}$ were equal before performing the two-sample t-test. An F-test (Likelihood Ratio Test) was used for both variables RFO and AGTRACT. The hypotheses was $H_0: \sigma_{640}^2/\sigma_{320}^2=1$ vs $H_a: \sigma_{640}^2/\sigma_{320}^2 \neq 1$, and the

test statistic was $f_0 = s_{320}^2 / s_{640}^2$. Results are shown in Table 4 below.

Table 4: F statistics for the variables RFO and AGTRACT

| STATE | STRATA | RFO F- STATISTIC | TWO-SIDED P-VALUE | RFO DF* 320 | RFO DF* 640 |
|----------------|--------|---------------------|----------------------|----------------|----------------|
| OHIO | 11 | 1.069 | 0.867 | 59.2 | 28.7 |
| OHIO | 12 | 0.792 | 0.678 | 11.6 | 4.0 |
| NORTH CAROLINA | 13 | 3.450 | 0.435 | 6.9 | 2.3 |
| NORTH CAROLINA | 20 | 0.608 | 0.211 | 93.5 | 10.1 |

| STATE | STRATA | AGT F- STATISTIC | TWO-SIDED P-VALUE | AGT DF* 320 | AGT DF* 640 |
|----------------|--------|---------------------|----------------------|----------------|----------------|
| OHIO | 11 | 1.218 | 0.489 | 69.9 | 43.8 |
| OHIO | 12 | 0.841 | 0.754 | 8.4 | 3.5 |
| NORTH CAROLINA | 13 | 2.482 | 0.546 | 8.5 | 2.6 |
| NORTH CAROLINA | 20 | 0.724 | 0.282 | 99.4 | 22.4 |

* DF ESTIMATED USING SATTERTHWAITE (SEE APPENDIX B)

Since all of the p-values were very large, we failed to reject the null hypothesis that the variances were equal. Hence, the assumption for the two sample t-test requiring equal variances was satisfied. Since SD-320 and SD-640 are both estimating either the mean number of resident farm operators or the mean number of agricultural tracts "per equal sized segment", one would expect that the two means would be very similar. Recall that both means were expressed in counts per 100 acres. The two-sample t-test with hypotheses, $H_0: \mu_{320} = \mu_{640}$ versus $H_a: \mu_{320} \neq \mu_{640}$ with test statistic $t_0 = (\bar{y}_{640} - \bar{x}_{320}) / (s_p \sqrt{1/n_1 + 1/n_2})$ where $s_p = [(1-n_1) * s_{320}^2 + (1-n_2) * s_{640}^2] / (n_1 + n_2 - 2)$, yielded the following results:

Table 5: T statistics for the variables RFO and AGTRACT

| STATE STRATA | RFO T- STATISTIC | TWO-SIDED P-VALUE | RFO DF* | AGT T- STATISTIC | TWO-SIDED P-VALUE | AGT DF* |
|-----------------|---------------------|----------------------|------------|---------------------|----------------------|------------|
| OH 11 | -2.856 | 0.005 | 85.9 | -0.774 | 0.440 | 111.7 |
| OH 12 | -2.843 | 0.013 | 13.6 | -2.220 | 0.051 | 9.9 |
| NC 13 | -1.757 | 0.122 | 7.1 | -1.845 | 0.098 | 9.0 |
| NC 20 | 1.007 | 0.317 | 101.6 | -0.671 | 0.504 | 119.9 |

* DF ESTIMATED USING SATTERTHWAITE (SEE APPENDIX B)

The only significant result occurred in stratum 11 for Ohio for the variable RFO. Although Ohio's stratum 12 appeared significant for both the variables RFO and AGTRACT, no conclusions were made due to the insufficient degrees of freedom. Based on the data, the significant case indicated that SD-320 had a higher mean "per equal sized segment" than SD-640. In addition, when all the means were expressed in terms of 100 acres, the mean for SD-320 was larger than the mean for SD-640 in every case, except for North Carolina's stratum 20 for the variable RFO (see Appendix C).

COMMENTS

The above analysis looks at the comparison of SD-320 versus SD-640 using a two-sample t-test based on the Central Limit Theorem, which states that as n grows large the distribution of the sample mean tends towards normality. However, in strata 12 and 13, the estimated degrees of freedom from the Satterthwaite formula cannot be considered large, which makes it difficult to make any statistical conclusions. Even though the data consists of discrete counts of resident farm operators (RFO's) and agricultural tracts (AGTRACT's), strata 11 and 20 can confidently be assumed to follow a normal distribution via the Central Limit Theorem Assumptions.

CONCLUSIONS

Comparing the expected totals from a simulated sample design for a 320 acre target segment size with a corresponding design for the 640 acre target segment size, resulted in SD-640 having more resident farm operators, agricultural tracts, and land. However, all the ratios of expected totals of SD-640 to SD-320 for RFO's and AGTRACT's were less than 2. Hence, more area must be sampled for SD-640 to achieve the same number of resident farm operators or agricultural tracts as SD-320. When comparing SD-320 to SD-640 for equal sized segments, there appeared to be no significant difference between the variances, therefore the precision of the estimates from either sampling scheme was essentially the same. A two-sample t-test was used to assess any difference in regards to the mean number of resident farm operators (RFO) and mean number of agricultural tracts (AGTRACT) for SD-320 to SD-640. No significant differences were found for the land use strata in North Carolina for either variable. A significant difference did occur in stratum 11 for Ohio between the two designs for the mean number of resident farm operators. In this significant case, the estimated mean "per equal size segment" was larger for SD-320 as compared to SD-640.

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APPENDIX A: AREA FRAME DESIGN INFORMATION

(37)

NORTH CAROLINA

| STRATUM | TOTAL SQUARE MILES | TARGET SEGMENT SIZE | NUMBER OF SEGMENTS IN POPULATION | NUMBER OF SEGMENTS IN SAMPLE | NUMBER OF SUBSTRATA | STRATUM DEFINITION |
|---------|--------------------------|---------------------------|--|------------------------------------|---------------------------|-----------------------|
| 13 | 1469 | 0.50 | 2938 | 18 | 6 | >50% CULTIVATED |
| 13 | 980 | 1.00 | 981 | 12 | 6 | >50% CULTIVATED |
| 20 | 16419 | 0.50 | 32834 | 140 | 14 | 15-50% CULTIVATED |
| 20 | 6568 | 1.00 | 6538 | 56 | 14 | 15-50% CULTIVATED |

(39)

OHIO

| STRATUM | TOTAL SQUARE MILES | TARGET SEGMENT SIZE | NUMBER OF SEGMENTS IN POPULATION | NUMBER OF SEGMENTS IN SAMPLE | NUMBER OF SUBSTRATA | STRATUM DEFINITION |
|---------|--------------------------|---------------------------|--|------------------------------------|---------------------------|-----------------------|
| 11 | 8602 | 0.50 | 17203 | 84 | 7 | >75% CULTIVATED |
| 11 | 5735 | 1.00 | 5735 | 56 | 7 | >75% CULTIVATED |
| 12 | 3763 | 0.50 | 7514 | 33 | 11 | 15-51% CULTIVATED |
| 12 | 2508 | 1.00 | 2510 | 22 | 11 | 15-51% CULTIVATED |

APPENDIX B: FORMULAS FOR ESTIMATES OF MEANS, VARIANCES, DEGREES OF FREEDOM AND SAMPLE TOTALS

The sample estimate of the population mean μ for a stratified random sample is defined as follows:

$$\bar{y}_{st} = \sum_{h=1}^L (N_h * \bar{y}_h) / N$$

where L = the number of paper strata in the land use stratum

N_h = the number of segments in paper stratum h (substrata h)

$N = N_1 + N_2 + \dots + N_L$
the total number of segments in the land use stratum

$\bar{y}_h = 1/n_h \sum_{i=1}^{n_h} y_{hi}$
the estimated mean number of RFO's (or AGTRACT's) in paper stratum h

where n_h = the number of segments sampled in paper stratum h

y_{hi} = the number of RFO's (or AGTRACT's) for segment i in paper stratum h

The estimated variance of \bar{y}_{st} is as follows:

$$\hat{V}(\bar{y}_{st}) = (1/N^2) \sum_{h=1}^L N_h * (N_h - n_h) * (s_h^2 / n_h)$$

where L, N, y_{hi}, \bar{y}_h , and n_h are the same as defined above and

$$s_h^2 = [1/(n_h - 1)] \sum_{i=1}^{n_h} (y_{hi} - \bar{y}_h)^2$$

the sample variance for paper stratum h

An approximation to the appropriate degrees of freedom is as follows (Satterthwaite, 1946):

$$DF = \frac{\sum_{h=1}^L (g_h * s_h^2)^2}{\sum_{h=1}^L \{ (g_h^2 * s_h^2) / (n_h - 1) \}}$$

where $g_h = (N_h(N_h - n_h)) / n_h$

APPENDIX B (CONT'D):

The estimated total number of RFO's (or AGTRACT's) in a sample from the 320 acre segment sampling scheme was computed as follows:

$$E[\text{total from sample}] = n_{320} * \overline{Y}_{320}$$

where n_{320} = the number of 320 acre
segments sampled in the
1989 JAS for a particular
stratum

\overline{Y}_{320} = the stratified mean number
of RFO's (or AGTRACT's)
for a particular stratum

NOTE: the estimated total number of RFO's (or AGTRACT's) in a sample from the 640 acre sampling scheme is found similarly)

APPENDIX C:
STRATIFIED ESTIMATES FOR MEAN AND VARIANCE (NOTE: ADJUSTED ESTIMATES A
BASED ON A COMMON SEGMENT SIZE OF 100 ACRES)

RFO

| STRATUM STATE | SEGMENT SIZE | ESTIMATED MEAN | ESTIMATED VARIANCE | ESTIMATED D.F. | ADJUSTED EST MEAN | ADJUSTED EST VAR |
|------------------|-----------------|-------------------|-----------------------|-------------------|----------------------|---------------------|
| 11 OH | 320 | 1.238 | 0.0145 | 59.2 | 0.387 | 0.00142 |
| 11 OH | 640 | 2.321 | 0.0543 | 28.7 | 0.363 | 0.00133 |
| 12 OH | 320 | 1.818 | 0.0521 | 11.6 | 0.568 | 0.00509 |
| 12 OH | 640 | 2.863 | 0.2633 | 4.0 | 0.447 | 0.00643 |
| 13 NC | 320 | 1.111 | 0.0828 | 6.9 | 0.347 | 0.00809 |
| 13 NC | 640 | 1.500 | 0.0960 | 2.3 | 0.234 | 0.00234 |
| 20 NC | 320 | 0.729 | 0.0078 | 93.5 | 0.228 | 0.00077 |
| 20 NC | 640 | 1.518 | 0.0515 | 10.1 | 0.237 | 0.00126 |

AGTRACT

| STRATUM STATE | SEGMENT SIZE | ESTIMATED MEAN | ESTIMATED VARIANCE | ESTIMATED D.F. | ADJUSTED EST MEAN | ADJUSTED EST VAR |
|------------------|-----------------|-------------------|-----------------------|-------------------|----------------------|---------------------|
| 11 OH | 320 | 3.988 | 0.0312 | 69.9 | 1.246 | 0.00304 |
| 11 OH | 640 | 6.607 | 0.1024 | 43.8 | 1.032 | 0.00250 |
| 12 OH | 320 | 4.030 | 0.0770 | 8.4 | 1.259 | 0.00752 |
| 12 OH | 640 | 6.088 | 0.3663 | 3.5 | 0.951 | 0.00894 |
| 13 NC | 320 | 4.333 | 0.4172 | 8.5 | 1.354 | 0.04074 |
| 13 NC | 640 | 5.500 | 0.6722 | 2.6 | 0.859 | 0.01641 |
| 20 NC | 320 | 2.928 | 0.0295 | 99.4 | 0.915 | 0.00288 |
| 20 NC | 640 | 4.839 | 0.1628 | 22.4 | 0.756 | 0.00398 |

APPENDIX D: OHIO DATA SUMMED TO THE PAPER STRATA LEVEL

OHIO STRATUM 11 RESIDENT FARM OPERATOR

| PAPER STRATA | SEGMENT SIZE | RFO n_i | RFO MEAN | RFO SUM | RFO VARIANCE |
|-----------------|-----------------|--------------|-------------|------------|-----------------|
| 1101 | 320 | 12 | 1.083 | 13 | 1.356 |
| 1101 | 640 | 8 | 1.875 | 15 | 0.411 |
| 1102 | 320 | 12 | 1.667 | 20 | 2.424 |
| 1102 | 640 | 8 | 3.000 | 24 | 5.143 |
| 1103 | 320 | 12 | 1.750 | 21 | 1.659 |
| 1103 | 640 | 8 | 3.875 | 31 | 2.696 |
| 1104 | 320 | 12 | 1.333 | 16 | 0.424 |
| 1104 | 640 | 8 | 1.875 | 15 | 0.411 |
| 1105 | 320 | 12 | 0.667 | 8 | 0.424 |
| 1105 | 640 | 8 | 2.750 | 22 | 8.214 |
| 1106 | 320 | 12 | 0.917 | 11 | 0.811 |
| 1106 | 640 | 8 | 1.125 | 9 | 1.839 |
| 1107 | 320 | 12 | 1.250 | 15 | 1.477 |
| 1107 | 640 | 8 | 1.750 | 14 | 2.786 |

OHIO STRATUM 11 AGRICULTURAL TRACT

| PAPER STRATA | SEGMENT SIZE | AGTRACT n_i | AGTRACT MEAN | AGTRACT SUM | AGTRACT VARIANCE |
|-----------------|-----------------|------------------|-----------------|----------------|---------------------|
| 1101 | 320 | 12 | 4.750 | 57 | 1.841 |
| 1101 | 640 | 8 | 8.000 | 64 | 3.429 |
| 1102 | 320 | 12 | 4.167 | 50 | 3.061 |
| 1102 | 640 | 8 | 6.750 | 54 | 5.071 |
| 1103 | 320 | 12 | 4.083 | 49 | 3.356 |
| 1103 | 640 | 8 | 8.250 | 66 | 8.500 |
| 1104 | 320 | 12 | 4.250 | 51 | 2.568 |
| 1104 | 640 | 8 | 6.500 | 52 | 2.571 |
| 1105 | 320 | 12 | 3.833 | 46 | 1.242 |
| 1105 | 640 | 8 | 6.500 | 52 | 6.857 |
| 1106 | 320 | 12 | 2.917 | 35 | 2.447 |
| 1106 | 640 | 8 | 4.375 | 35 | 7.125 |
| 1107 | 320 | 12 | 3.917 | 47 | 3.902 |
| 1107 | 640 | 8 | 5.875 | 47 | 6.982 |

APPENDIX D: OHIO DATA SUMMED TO PAPER STRATA LEVEL

OHIO STRATUM 12 RESIDENT FARM OPERATOR

| PAPER STRATA | SEGMENT SIZE | RFO n_i | RFO MEAN | RFO SUM | RFO VARIANCE |
|-----------------|-----------------|--------------|-------------|------------|-----------------|
| 1201 | 320 | 3 | 3.00 | 9 | 1.00 |
| 1201 | 640 | 2 | 3.50 | 7 | 24.50 |
| 1202 | 320 | 3 | 1.67 | 5 | 2.33 |
| 1202 | 640 | 2 | 2.00 | 4 | 0.00 |
| 1203 | 320 | 3 | 1.67 | 5 | 1.33 |
| 1203 | 640 | 2 | 2.50 | 5 | 4.50 |
| 1204 | 320 | 3 | 1.33 | 4 | 0.33 |
| 1204 | 640 | 2 | 1.50 | 3 | 4.50 |
| 1205 | 320 | 3 | 1.00 | 3 | 1.00 |
| 1205 | 640 | 2 | 3.00 | 6 | 8.00 |
| 1206 | 320 | 3 | 1.67 | 5 | 1.33 |
| 1206 | 640 | 2 | 3.50 | 7 | 0.50 |
| 1207 | 320 | 3 | 0.33 | 1 | 0.33 |
| 1207 | 640 | 2 | 4.00 | 8 | 2.00 |
| 1208 | 320 | 3 | 1.67 | 5 | 2.33 |
| 1208 | 640 | 2 | 3.00 | 6 | 0.00 |
| 1209 | 320 | 3 | 2.67 | 8 | 0.33 |
| 1209 | 640 | 2 | 2.50 | 5 | 0.50 |
| 1210 | 320 | 3 | 3.67 | 11 | 6.33 |
| 1210 | 640 | 2 | 2.00 | 4 | 2.00 |
| 1211 | 320 | 3 | 1.33 | 4 | 2.33 |
| 1211 | 640 | 2 | 4.00 | 8 | 18.00 |

OHIO STRATUM 12 AGRICULTURAL TRACT

| PAPER STRATA | SEGMENT SIZE | AGTRACT n_i | AGTRACT MEAN | AGTRACT SUM | AGTRACT VARIANCE |
|-----------------|-----------------|------------------|-----------------|----------------|---------------------|
| 1201 | 320 | 3 | 5.33 | 16 | 1.33 |
| 1201 | 640 | 2 | 6.00 | 12 | 8.00 |
| 1202 | 320 | 3 | 3.33 | 10 | 2.33 |
| 1202 | 640 | 2 | 5.50 | 11 | 0.50 |
| 1203 | 320 | 3 | 4.00 | 12 | 0.00 |
| 1203 | 640 | 2 | 7.00 | 14 | 2.00 |
| 1204 | 320 | 3 | 3.33 | 10 | 1.33 |
| 1204 | 640 | 2 | 3.00 | 6 | 0.00 |
| 1205 | 320 | 3 | 3.33 | 10 | 2.33 |
| 1205 | 640 | 2 | 4.50 | 9 | 24.50 |
| 1206 | 320 | 3 | 4.00 | 12 | 3.00 |
| 1206 | 640 | 2 | 5.50 | 11 | 0.50 |
| 1207 | 320 | 3 | 2.33 | 7 | 0.33 |
| 1207 | 640 | 2 | 7.50 | 15 | 4.50 |
| 1208 | 320 | 3 | 4.67 | 14 | 1.33 |
| 1208 | 640 | 2 | 7.50 | 15 | 0.50 |
| 1209 | 320 | 3 | 4.67 | 14 | 1.33 |
| 1209 | 640 | 2 | 6.50 | 13 | 4.50 |
| 1210 | 320 | 3 | 5.67 | 17 | 2.33 |
| 1210 | 640 | 2 | 4.50 | 9 | 4.50 |
| 1211 | 320 | 3 | 3.67 | 11 | 12.33 |
| 1211 | 640 | 2 | 9.50 | 19 | 40.50 |

APPENDIX D: NORTH CAROLINA DATA SUMMED TO PAPER STRATA LEVEL

NORTH CAROLINA STRATUM 13 RESIDENT FARM OPERATOR

| PAPER STRATA | SEGMENT SIZE | RFO n_i | RFO MEAN | RFO SUM | RFO VARIANCE |
|-----------------|-----------------|--------------|-------------|------------|-----------------|
| 1301 | 320 | 3 | 0.67 | 2 | 0.33 |
| 1301 | 640 | 2 | 1.50 | 3 | 0.50 |
| 1302 | 320 | 3 | 0.00 | 0 | 0.00 |
| 1302 | 640 | 2 | 0.50 | 1 | 0.50 |
| 1303 | 320 | 3 | 1.00 | 3 | 3.00 |
| 1303 | 640 | 2 | 1.50 | 3 | 4.50 |
| 1304 | 320 | 3 | 1.33 | 4 | 0.33 |
| 1304 | 640 | 2 | 1.50 | 3 | 0.50 |
| 1305 | 320 | 3 | 2.00 | 6 | 3.00 |
| 1305 | 640 | 2 | 2.50 | 5 | 0.50 |
| 1306 | 320 | 3 | 1.67 | 5 | 2.33 |
| 1306 | 640 | 2 | 1.50 | 3 | 0.50 |

NORTH CAROLINA STRATUM 12 AGRICULTURAL TRACT

| PAPER STRATA | SEGMENT SIZE | AGTRACT n_i | AGTRACT MEAN | AGTRACT SUM | AGTRACT VARIANCE |
|-----------------|-----------------|------------------|-----------------|----------------|---------------------|
| 1301 | 320 | 3 | 4.00 | 12 | 9.00 |
| 1301 | 640 | 2 | 5.00 | 10 | 2.00 |
| 1302 | 320 | 3 | 2.33 | 7 | 2.33 |
| 1302 | 640 | 2 | 4.00 | 8 | 2.00 |
| 1303 | 320 | 3 | 5.00 | 15 | 13.00 |
| 1303 | 640 | 2 | 6.50 | 13 | 24.50 |
| 1304 | 320 | 3 | 5.67 | 17 | 2.33 |
| 1304 | 640 | 2 | 6.50 | 13 | 0.50 |
| 1305 | 320 | 3 | 4.67 | 14 | 4.33 |
| 1305 | 640 | 2 | 7.00 | 14 | 2.00 |
| 1306 | 320 | 3 | 4.33 | 13 | 14.33 |
| 1306 | 640 | 2 | 4.00 | 8 | 18.00 |

APPENDIX D: NORTH CAROLINA DATA SUMMED TO PAPER STRATA LEVEL

NORTH CAROLINA STRATUM 20 RESIDENT FARM OPERATOR

| PAPER STRATA | SEGMENT SIZE | RFO n _i | RFO MEAN | RFO SUM | RFO VARIANCE |
|-----------------|-----------------|-----------------------|-------------|------------|-----------------|
| 2001 | 320 | 10 | 0.10 | 1 | 0.10 |
| 2001 | 640 | 4 | 0.25 | 1 | 0.25 |
| 2002 | 320 | 10 | 0.30 | 3 | 0.90 |
| 2002 | 640 | 4 | 1.75 | 7 | 1.58 |
| 2003 | 320 | 10 | 0.80 | 8 | 1.07 |
| 2003 | 640 | 4 | 1.00 | 4 | 0.67 |
| 2004 | 320 | 10 | 1.40 | 14 | 2.49 |
| 2004 | 640 | 4 | 0.50 | 2 | 1.00 |
| 2005 | 320 | 10 | 0.80 | 8 | 1.51 |
| 2005 | 640 | 4 | 1.25 | 5 | 0.92 |
| 2006 | 320 | 10 | 0.70 | 7 | 1.57 |
| 2006 | 640 | 4 | 3.25 | 13 | 20.92 |
| 2007 | 320 | 10 | 1.10 | 11 | 1.66 |
| 2007 | 640 | 4 | 3.25 | 13 | 0.92 |
| 2008 | 320 | 10 | 1.10 | 11 | 0.99 |
| 2008 | 640 | 4 | 0.50 | 2 | 0.33 |
| 2009 | 320 | 10 | 0.80 | 8 | 1.29 |
| 2009 | 640 | 4 | 2.00 | 8 | 2.00 |
| 2010 | 320 | 10 | 0.50 | 5 | 0.50 |
| 2010 | 640 | 4 | 1.00 | 4 | 1.33 |
| 2011 | 320 | 10 | 0.10 | 1 | 0.10 |
| 2011 | 640 | 4 | 1.00 | 4 | 0.67 |
| 2012 | 320 | 10 | 1.10 | 11 | 0.99 |
| 2012 | 640 | 4 | 2.25 | 9 | 4.917 |
| 2013 | 320 | 10 | 1.00 | 10 | 1.778 |
| 2013 | 640 | 4 | 2.50 | 10 | 4.333 |
| 2014 | 320 | 10 | 0.40 | 4 | 0.489 |
| 2014 | 640 | 4 | 0.75 | 3 | 0.917 |

NORTH CAROLINA STRATUM 20 AGRICULTURAL TRACT

| PAPER STRATA | SEGMENT SIZE | AGTRACT n _i | AGTRACT MEAN | AGTRACT SUM | AGTRACT VARIANCE |
|-----------------|-----------------|---------------------------|-----------------|----------------|---------------------|
| 2001 | 320 | 10 | 2.00 | 20 | 1.33 |
| 2001 | 640 | 4 | 3.75 | 15 | 2.92 |
| 2002 | 320 | 10 | 3.00 | 30 | 3.33 |
| 2002 | 640 | 4 | 5.50 | 22 | 9.00 |
| 2003 | 320 | 10 | 3.10 | 31 | 6.10 |
| 2003 | 640 | 4 | 5.00 | 20 | 8.67 |
| 2004 | 320 | 10 | 4.00 | 40 | 2.67 |
| 2004 | 640 | 4 | 4.25 | 17 | 8.25 |
| 2005 | 320 | 10 | 3.70 | 37 | 5.57 |
| 2005 | 640 | 4 | 4.25 | 17 | 4.25 |
| 2006 | 320 | 10 | 4.60 | 46 | 8.49 |
| 2006 | 640 | 4 | 9.00 | 36 | 36.67 |
| 2007 | 320 | 10 | 2.80 | 28 | 5.96 |
| 2007 | 640 | 4 | 9.00 | 36 | 8.67 |
| 2008 | 320 | 10 | 3.70 | 37 | 3.12 |
| 2008 | 640 | 4 | 3.25 | 13 | 4.92 |
| 2009 | 320 | 10 | 2.40 | 24 | 6.71 |
| 2009 | 640 | 4 | 5.25 | 21 | 10.92 |
| 2010 | 320 | 10 | 1.70 | 17 | 1.79 |
| 2010 | 640 | 4 | 4.50 | 18 | 4.33 |
| 2011 | 320 | 10 | 2.00 | 20 | 1.33 |
| 2011 | 640 | 4 | 2.50 | 10 | 0.33 |
| 2012 | 320 | 10 | 3.30 | 33 | 4.23 |
| 2012 | 640 | 4 | 5.00 | 20 | 14.67 |
| 2013 | 320 | 10 | 3.20 | 32 | 5.07 |
| 2013 | 640 | 4 | 5.25 | 21 | 12.92 |
| 2014 | 320 | 10 | 1.50 | 15 | 2.28 |
| 2014 | 640 | 4 | 1.25 | 5 | 2.25 |

* U.S. G.P.O.:1992-311-404:60026/NASS

